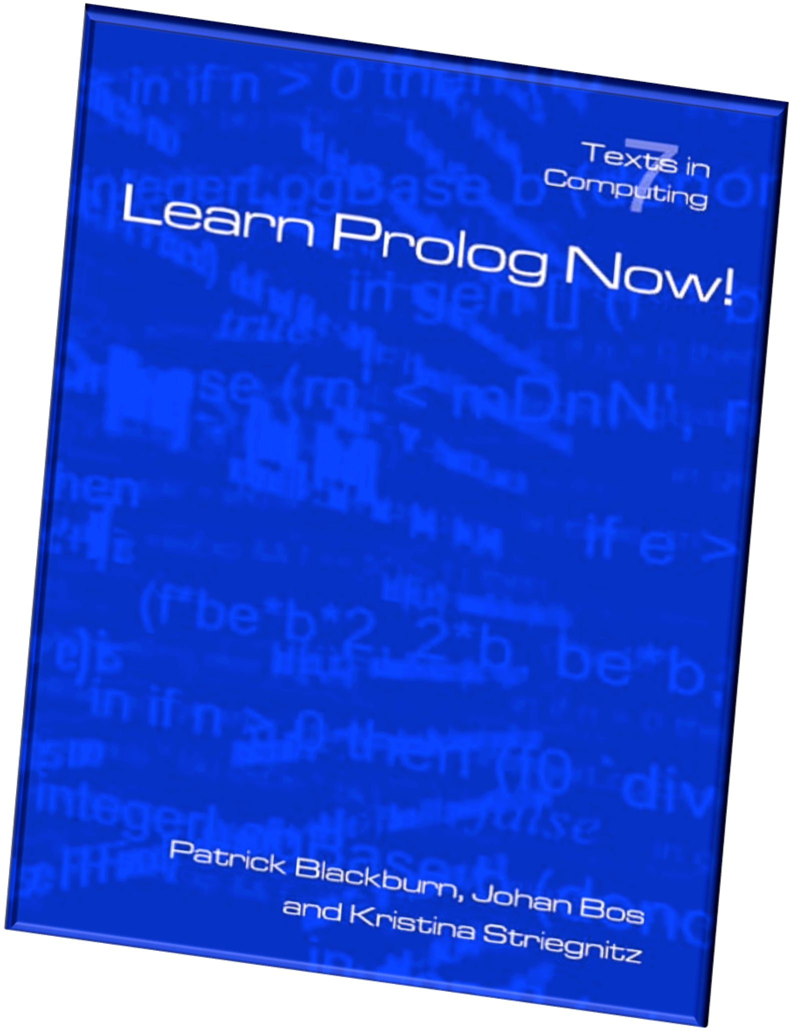
Learn Prolog Now!



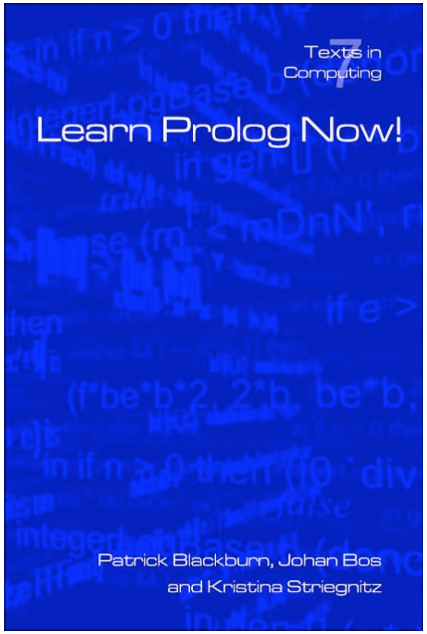
SWI Prolog

- Freely available Prolog interpreter
- Works with
  - Linux,
  - Windows, or
  - Mac OS
- There are many more Prolog interpreters
- Not all are ISO compliant/free

Lecture 1

- Theory
  - – Introduction to Prolog
  - – Facts, Rules and Queries
  - – Prolog Syntax

- Exercises
  - – Exercises of LPN chapter 1
  - – Practical work



Aim of this lecture (1/2)

- Give some simple examples of Prolog programs
- Discuss the three basic constructs in Prolog:
  - Facts
  - Rules
  - Queries

Aim of this lecture (2/2)

- Introduce other concepts, such as
  - the role of logic
  - unification with the help of variables
- Begin the systematic study of Prolog by defining
  - terms
  - atoms, and
  - variables

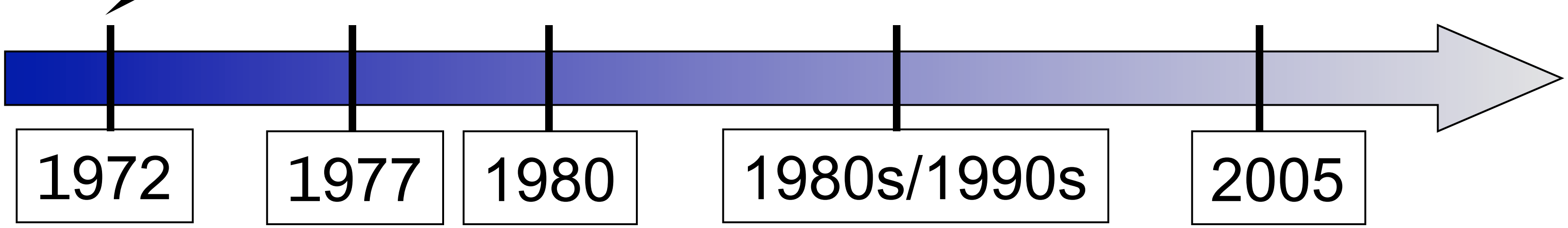
Prolog

- "Programming with Logic"
- Very different from other programming languages
  - Declarative (not procedural)
  - Recursion (no “for” or “while” loops)
  - Relations (no functions)
  - Unification

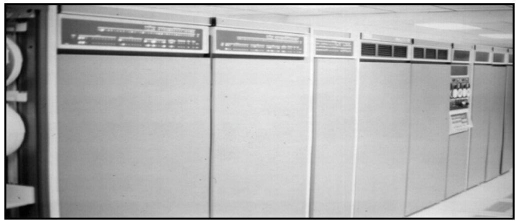
no explicit drection of computiton
Flexible

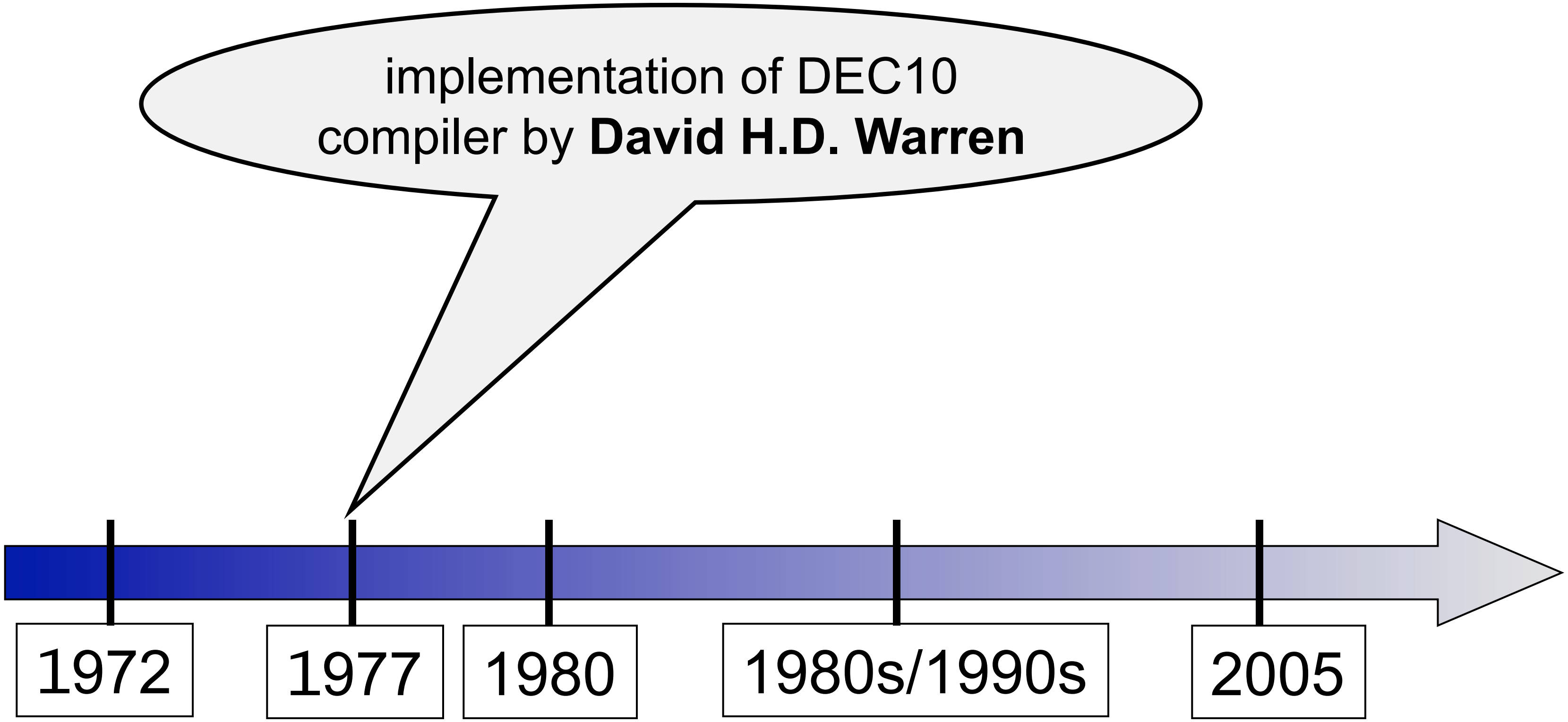
History of Prolog

first Prolog interpreter by **Alain Colmerauer** and **Philippe Roussel**



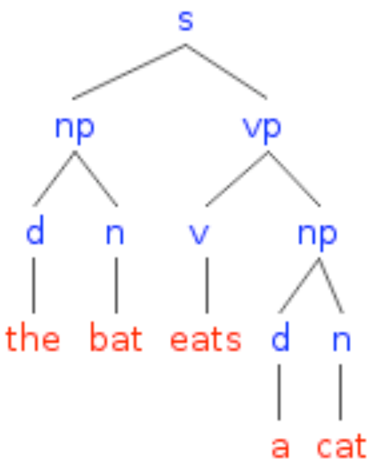
History of Prolog



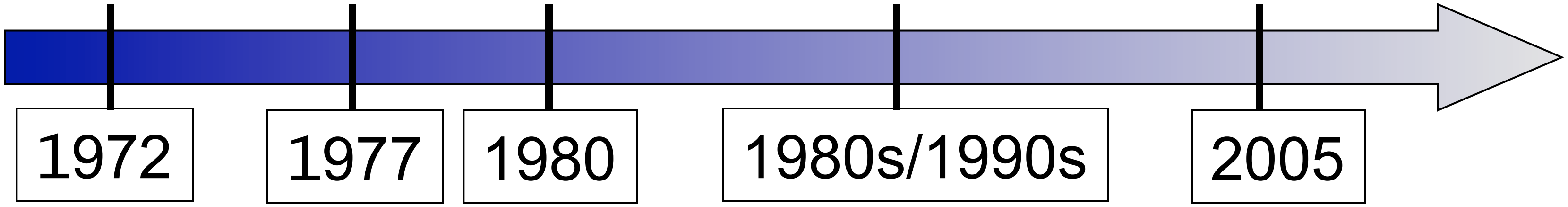


implementation of DEC10 compiler by **David H.D. Warren**

History of Prolog



Definite Clause Grammars implementation by **Pereira** and **Warren**


1972

1977

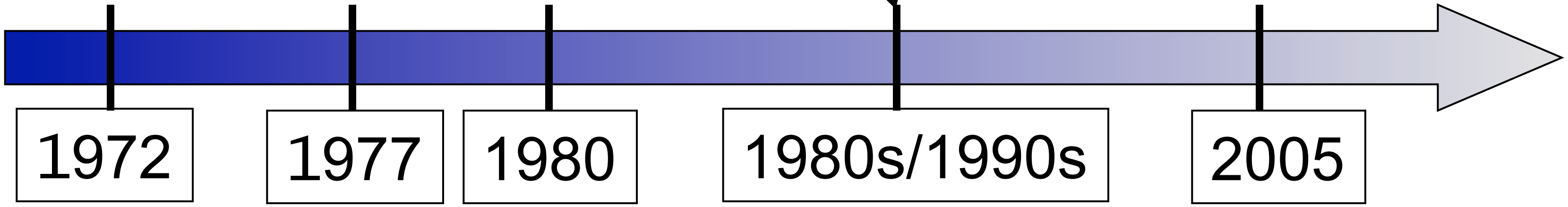
1980

1980s/1990s

2005

History of Prolog

Prolog grows in popularity especially in Japan and Europe



1972

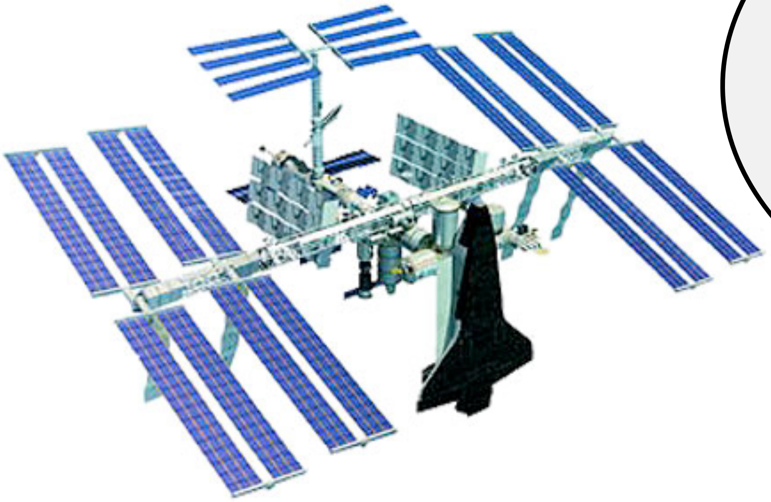
1977

1980

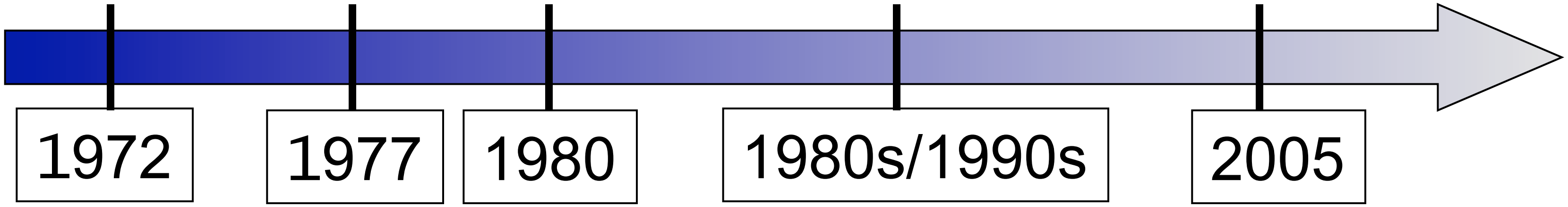
1980s/1990s

2005

History of Prolog



Prolog used to program natural language interface in International Space Station by NASA



1972

1977

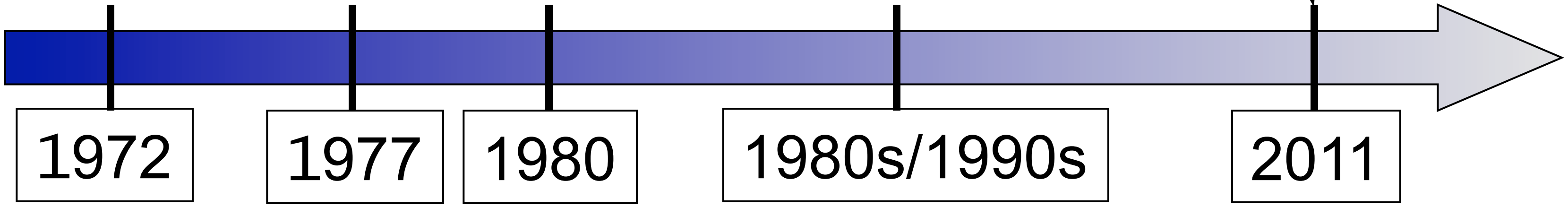
1980

1980s/1990s

2005

History of Prolog

Parts of IBM's Watson QA supercomputer were coded in Prolog



1972

1977

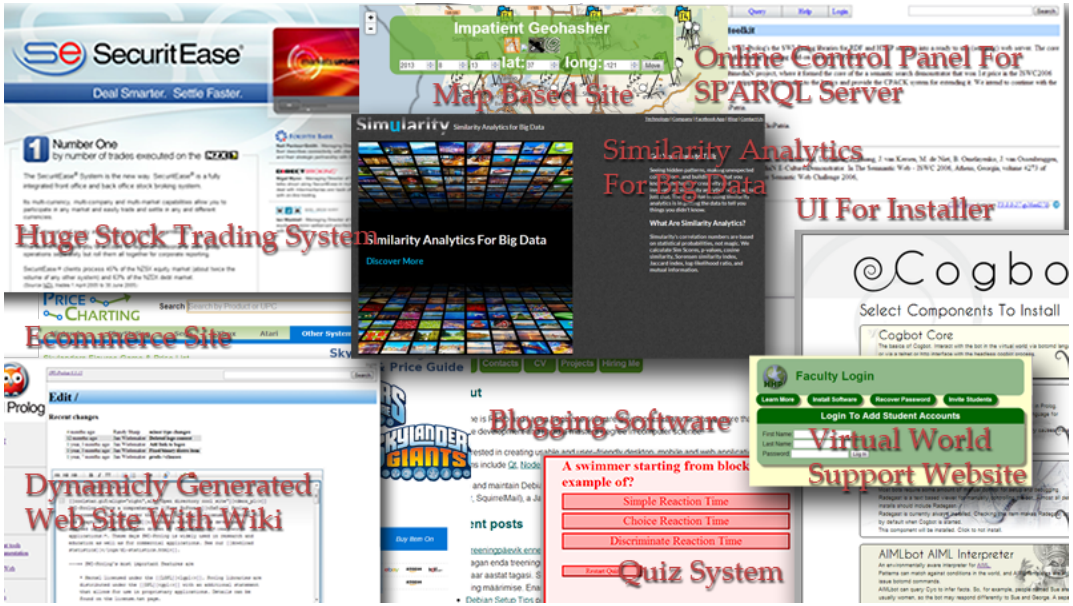
1980

1980s/1990s

2011

Prolog and Web Applications

- prolog programs are often smaller
- smallness encourages well written code
- hence, easier to maintain


Huge Stock Trading System
Map Based Site
Online Control Panel For SPARQL Server
Similarity Analytics For Big Data
UI For Installer
Ecommerce Site
Dynamicly Generated Web Site With Wiki
Blogging Software
Virtual World Support Website
Quiz System

Source:

http://www.pathwayslms.com/swipltuts/

Basic idea of Prolog

- Describe the situation of interest
- Ask a question
- Prolog:
  - logically deduces new facts about the situation we described
  - gives us its deductions back as answers

Consequences

- Think declaratively, not procedurally
  - Challenging
  - Requires a different mindset
- High-level language
  - Not as efficient as, say, C
  - Good for rapid prototyping
  - Useful in many AI applications (knowledge representation, inference)

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
yes
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
yes
?- playsAirGuitar(jody).
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
yes
?- playsAirGuitar(jody).
yes
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
yes
?- playsAirGuitar(jody).
yes
?- playsAirGuitar(mia).
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- woman(mia).
yes
?- playsAirGuitar(jody).
yes
?- playsAirGuitar(mia).
no
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- tattoed(jody).
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- tattoed(jody).
no
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- tattoed(jody).
ERROR: predicate tattoed/1 not defined.
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- party.
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- party.
yes
?-
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- rockConcert.
```

Knowledge Base 1

```
woman(mia).
woman(jody).
woman(yolanda).
playsAirGuitar(jody).
party.
```

```
?- rockConcert.
no
?-
```

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

fact

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

fact

fact

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

fact

fact

rule

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

fact

fact

rule

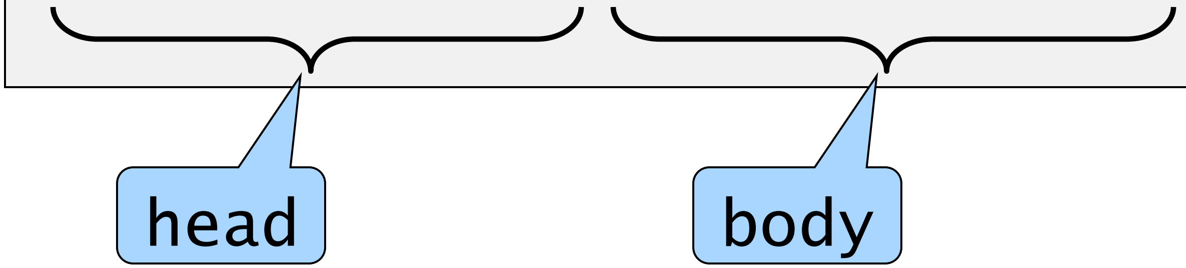
rule

Knowledge Base 2

```
happy(yolanda).                                    fact
listens2music(mia).                                fact
listens2music(yolanda):- happy(yolanda).           rule
playsAirGuitar(mia):- listens2music(mia).          rule
playsAirGuitar(yolanda):- listens2music(yolanda).  rule
```

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```



Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

```
?-
```

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

```
?- playsAirGuitar(mia).
yes
?-
```

Knowledge Base 2

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

```
?- playsAirGuitar(mia).
yes
?- playsAirGuitar(yolanda).
yes
```

Clauses

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

There are five clauses in this knowledge base: two facts, and three rules.

The end of a clause is marked with a full stop.

Predicates

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

*There are three **predicates** in this knowledge base:*

happy, listens2music, and playsAirGuitar

Knowledge Base 3

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

Expressing Conjunction

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

Birlesme

The comma "," expresses conjunction in Prolog

PROLOG da expressionlar soldan saa iterate eder. once subexpression 1 sonra subexppression 2.

Conjuction : A AND B

Knowledge Base 3

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

```
?- playsAirGuitar(vincent).
```

Knowledge Base 3

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

```
?- playsAirGuitar(vincent).
no
?-
```

Knowledge Base 3

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

```
?- playsAirGuitar(butch).
```

Knowledge Base 3

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

```
?- playsAirGuitar(butch).
yes
?-
```

Expressing Disjunction

; ile ayr yazmak yerine ayn statementa atabilirsin.

Disjunction : A OR B

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch).
playsAirGuitar(butch):- listens2music(butch).
```

```
happy(vincent).
listens2music(butch).
playsAirGuitar(vincent):- listens2music(vincent), happy(vincent).
playsAirGuitar(butch):- happy(butch); listens2music(butch).
```

Prolog and Logic

- Clearly, Prolog has something to do with logic...

		Prolog	Logic
B determines A B is subgoal a is goal	Implication	A :- B	B → A
A and B	Conjunction	A,B	A ∧ B
A or B	Disjunction	A;B	A ∨ B

- Use of inference (modus ponens)
- Negation (?)

Knowledge Base 4

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

Prolog Variables

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
```

Variable Instantiation

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
X=mia
```

Asking Alternatives

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
X=mia;
```

Asking Alternatives

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
X=mia;
X=jody
```

Asking Alternatives

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
X=mia;
X=jody;
X=yolanda
```

Asking Alternatives

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- woman(X).
X=mia;
X=jody;
X=yolanda;
no
```

Knowledge Base 4

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- loves(marsellus,X), woman(X).
```

Knowledge Base 4

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- loves(marsellus,X), woman(X).
X=mia
yes
?-
```

Knowledge Base 4

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- loves(pumpkin,X), woman(X).
```

Knowledge Base 4

```
woman(mia).
woman(jody).
woman(yolanda).

loves(vincent, mia).
loves(marsellus, mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).
```

```
?- loves(pumpkin,X), woman(X).
no
?-
```

Knowledge Base 5

```
loves(vincent,mia).
loves(marsellus,mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).

jealous(X,Y):- loves(X,Z), loves(Y,Z).
```

Knowledge Base 5

```
loves(vincent,mia).
loves(marsellus,mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).

jealous(X,Y):- loves(X,Z), loves(Y,Z).
```

```
?- jealous(marsellus,W).
```

Knowledge Base 5

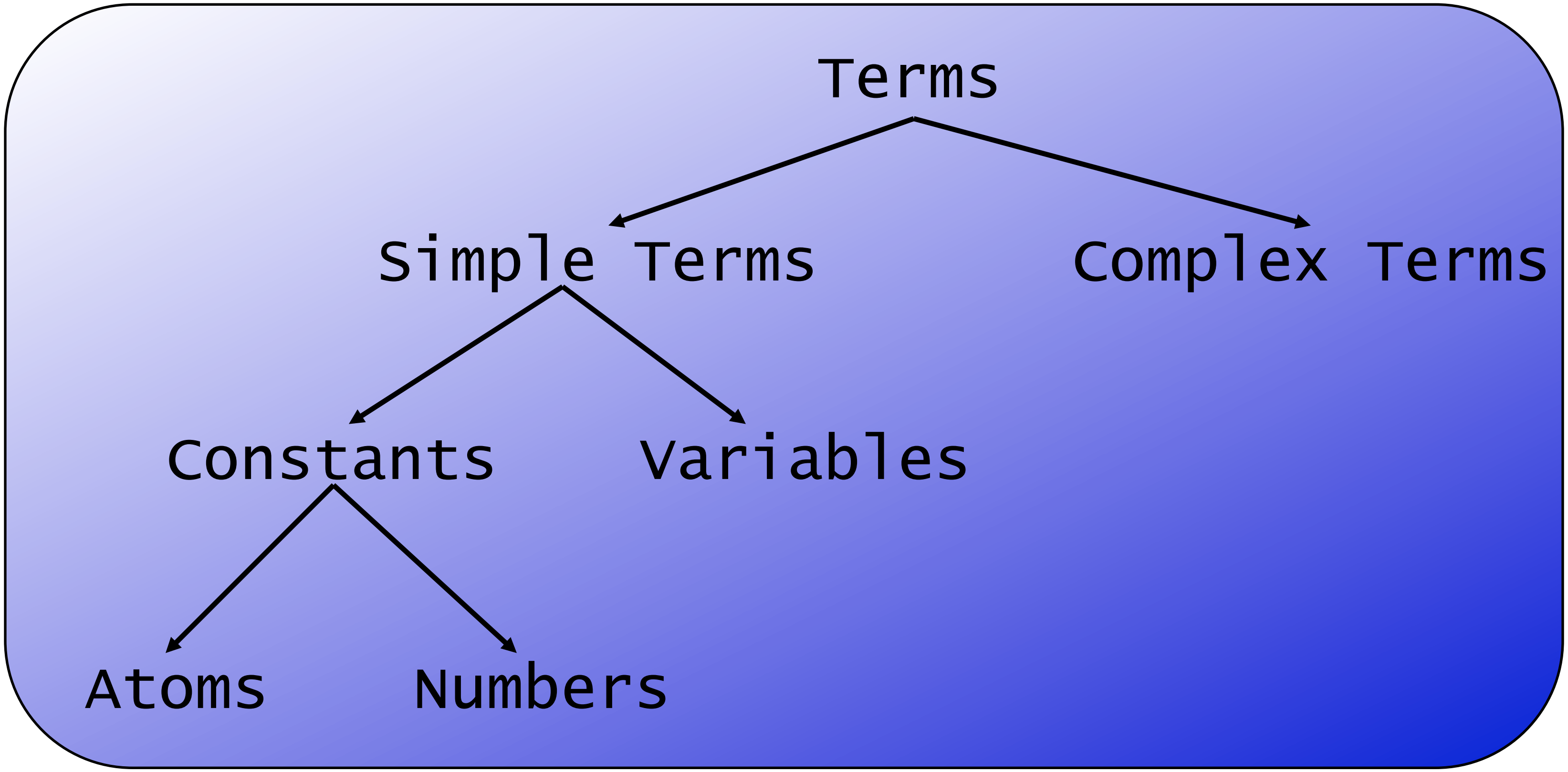
```
loves(vincent,mia).
loves(marsellus,mia).
loves(pumpkin, honey_bunny).
loves(honey_bunny, pumpkin).

jealous(X,Y):- loves(X,Z), loves(Y,Z).
```

```
?- jealous(marsellus,W).
W=vincent
?-
```

Syntax of Prolog

- Q: What exactly are facts, rules and queries built out of?
- A: Prolog terms

Prolog terms



Terms

Simple Terms

Complex Terms

Constants

Variables

Atoms

Numbers

Atoms

- A sequence of characters of upper-case letters, lower-case letters, digits, or underscore, starting with a lowercase letter
  - *Examples*: **butch**, **big_kahuna_burger**, **playGuitar**

Atoms

- A sequence of characters of upper-case letters, lower-case letters, digits, or underscore, starting with a lowercase letter
  - *Examples*: **butch**, **big_kahuna_burger**, **playGuitar**

- An arbitrary sequence of characters enclosed in single quotes
  - *Examples*: **'Vincent'**, **'Five dollar shake'**, **'@$%'**

Atoms

- A sequence of characters of upper-case letters, lower-case letters, digits, or underscore, starting with a lowercase letter
  - *Examples*: **butch**, **big_kahuna_burger**, **playGuitar**
- An arbitrary sequence of characters enclosed in single quotes
  - *Examples*: **'Vincent'**, **'Five dollar shake'**, **'@$%'**
- A sequence of special characters
  - *Examples*: **:** **,** **;** **.** **:-**

Numbers

- Integers:

  12,   -34,   22342

- Floats:

  34573.3234, 0.3435

Variables

- A sequence of characters of upper-case letters, lower-case letters, digits, or underscore, starting with either an uppercase letter or an underscore

- Examples:

  X, Y, Variable, Vincent, _tag

Complex Terms

- Atoms, numbers and variables are building blocks for **complex terms**
- Complex terms are built out of a **functor** directly followed by a sequence of **arguments**
  - Arguments are put in round brackets, separated by commas
  - The functor must be an atom

Examples of complex terms

- Examples we have seen before:
  - playsAirGuitar(jody)
  - loves(vincent, mia)
  - jealous(marsellus, W)

Complex terms builted with atoms,numbers and variables.

functor(arguements)

- Complex terms inside complex terms:
  - hide(X,father(father(father(butch))))

Arity

- The number of arguments a complex term has is called its arity

- Examples:

woman(mia)	is a term with arity 1
loves(vincent,mia)	has arity 2
father(father(butch))	arity 1

Arity is important

- You can define two predicates with the same functor but with different arity
- Prolog would treat this as two different predicates!
- In Prolog documentation, arity of a predicate is usually indicated with the suffix "/" followed by a number to indicate the arity

Example of Arity

```
happy(yolanda).
listens2music(mia).
listens2music(yolanda):- happy(yolanda).
playsAirGuitar(mia):- listens2music(mia).
playsAirGuitar(yolanda):- listens2music(yolanda).
```

- This knowledge base defines
  - happy/1
  - listens2music/1
  - playsAirGuitar/1